Influence of irrigation recharge on groundwater nitrate-N on the Greenfields Bench, MT

Christian G. Schmidt
Hydrologist
Montana Department of Agriculture
Ground Water Protection Program

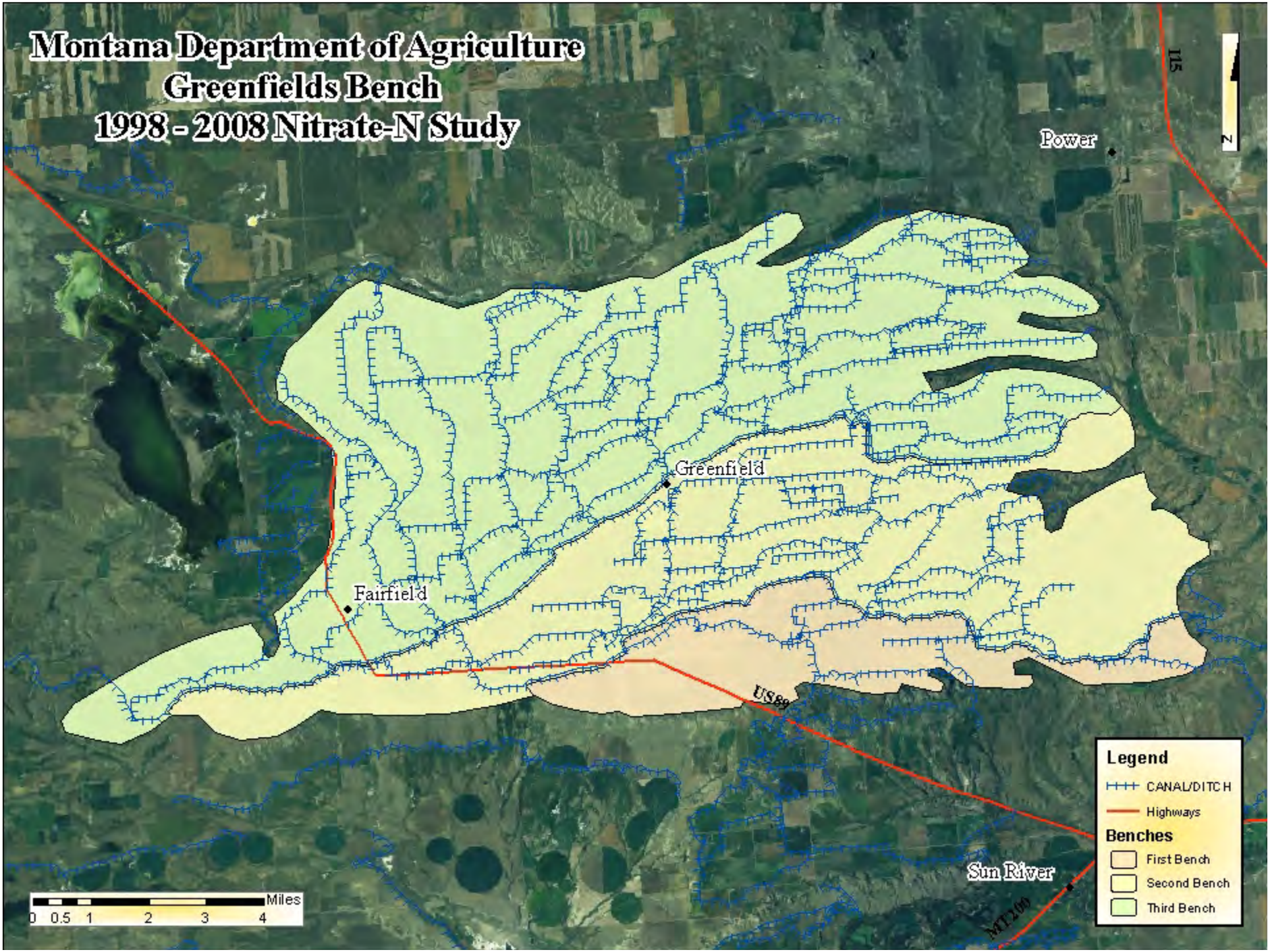
Montana Department of Agriculture

- In 1989, the Montana Agricultural Chemical Groundwater Protection Act was passed (MCA Title 80, Chapter 15, Sections 80-15-101 through 80-15-414). Section 80-15-103 states that it is the policy of the state to:
- protect groundwater and the environment from impairment or degradation due to the use of agricultural chemicals
- allow for the proper and correct use of agricultural chemicals
- provide for the management of agricultural chemicals to prevent, minimize, and mitigate their presence in groundwater
- provide for education and training of agricultural chemical applicators and the general public on groundwater protection, agricultural chemical use, and the use of alternative agricultural chemicals

Montana Department of Agriculture
Greenfields Bench
1998 - 2008 Nitrate-N Study

Greenfields Bench

- Greenfields Irrigation District supplies water to ~81,000 acres
- District fed by 3 reservoirs
  - Gibson Reservoir – 105,000 ac. ft. storage
  - Pishkun Reservoir – 32,050 ac. ft. storage
  - Willow Creek Reservoir – 32,300 ac. ft. storage
- 295 miles of canals and laterals
- Area known for production of malt barley

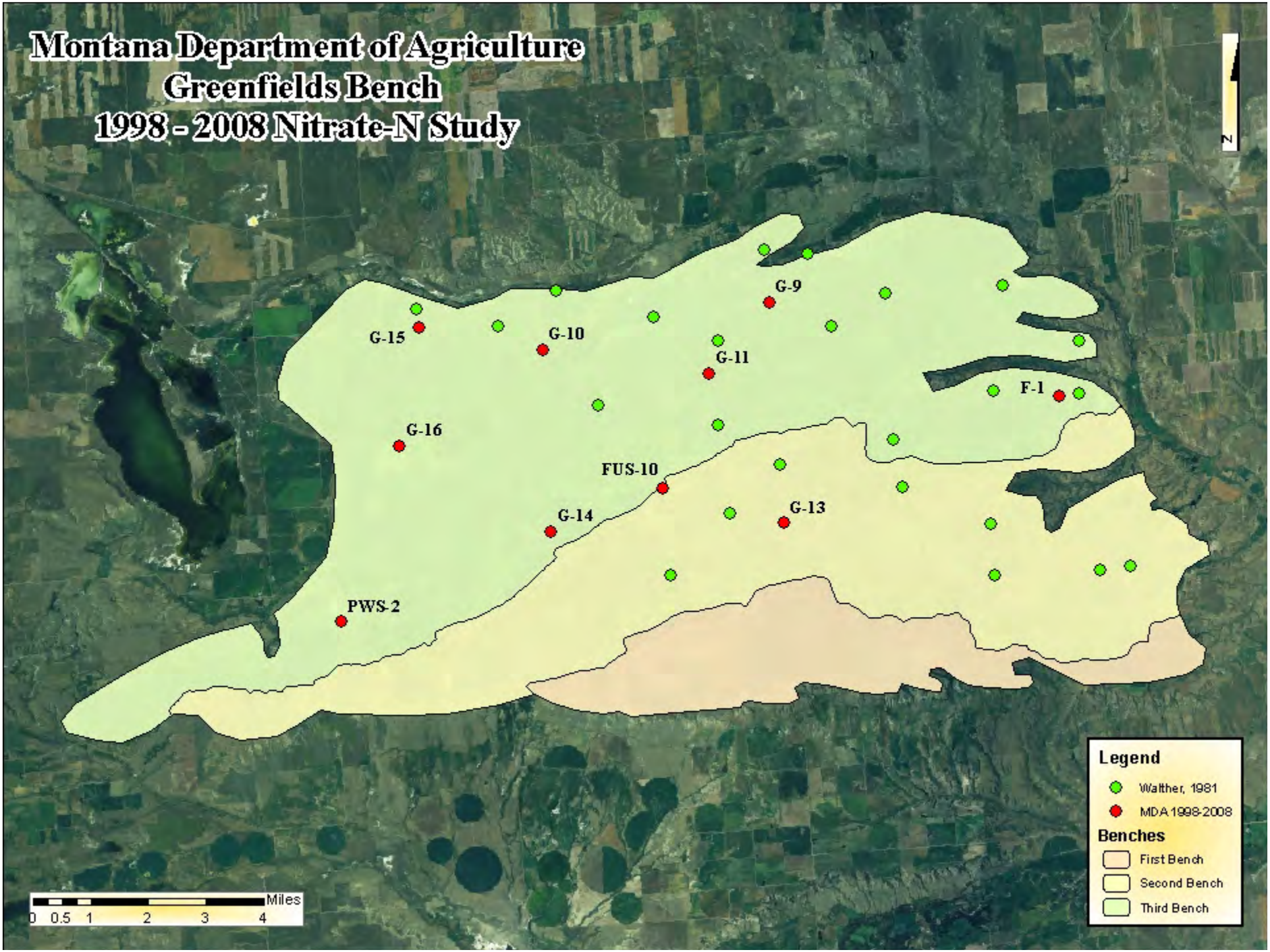

Montana Department of Agriculture
Greenfields Bench
1998 - 2008 Nitrate-N Study
Power
115
N
Greenfield
Fairfield
US89
Sun River
MT200
Legend
CANAL/DITCH
Highways
Benches
First Bench
Second Bench
Third Bench
0 0.5 1 2 3 4
Miles

Hydrogeology

- Topographically isolated bench of Cretaceous age
- Overlain by quaternary gravel deposits (1 to 12 m thick)
- Benches formed by downcutting and terrace gravel deposition of the Sun River (pre- and early Wisconsin Eras)
- Somewhat excessively drained clay loam soils (~ 2 cm thick) overlay poorly sorted sand and gravels in a clay matrix (Miller, 2005)
- Shallow aquifer recharged by irrigation/precipitation – direct hydraulic connection
  - 70% of recharge from irrigation, canal leakage, and ponded tailwater (Osborne et al., 1983)
  - During irrigation season (May-July) groundwater levels may rise to the ground surface

Data

- 10 groundwater wells with minimum of 5 years collection (mean=8.8 years) between 1998-2008 (*n*=171)
  - Growing season data (April – September)
- Climate data from Greenfields weather station (COOP ID: 242857)
- Comparison with dataset of earlier nitrate-N study on the Bench (*n*=261) (Walther, 1981)


Montana Department of Agriculture
Greenfields Bench
1998 - 2008 Nitrate-N Study
N
G-9
G-15
G-10
G-11
F-1
G-16
FUS-10
G-14
G-13
PWS-2
Legend
Walther, 1981
MDA 1998-2008
Benches
First Bench
Second Bench
Third Bench
Miles
0 0.5 1 2 3 4

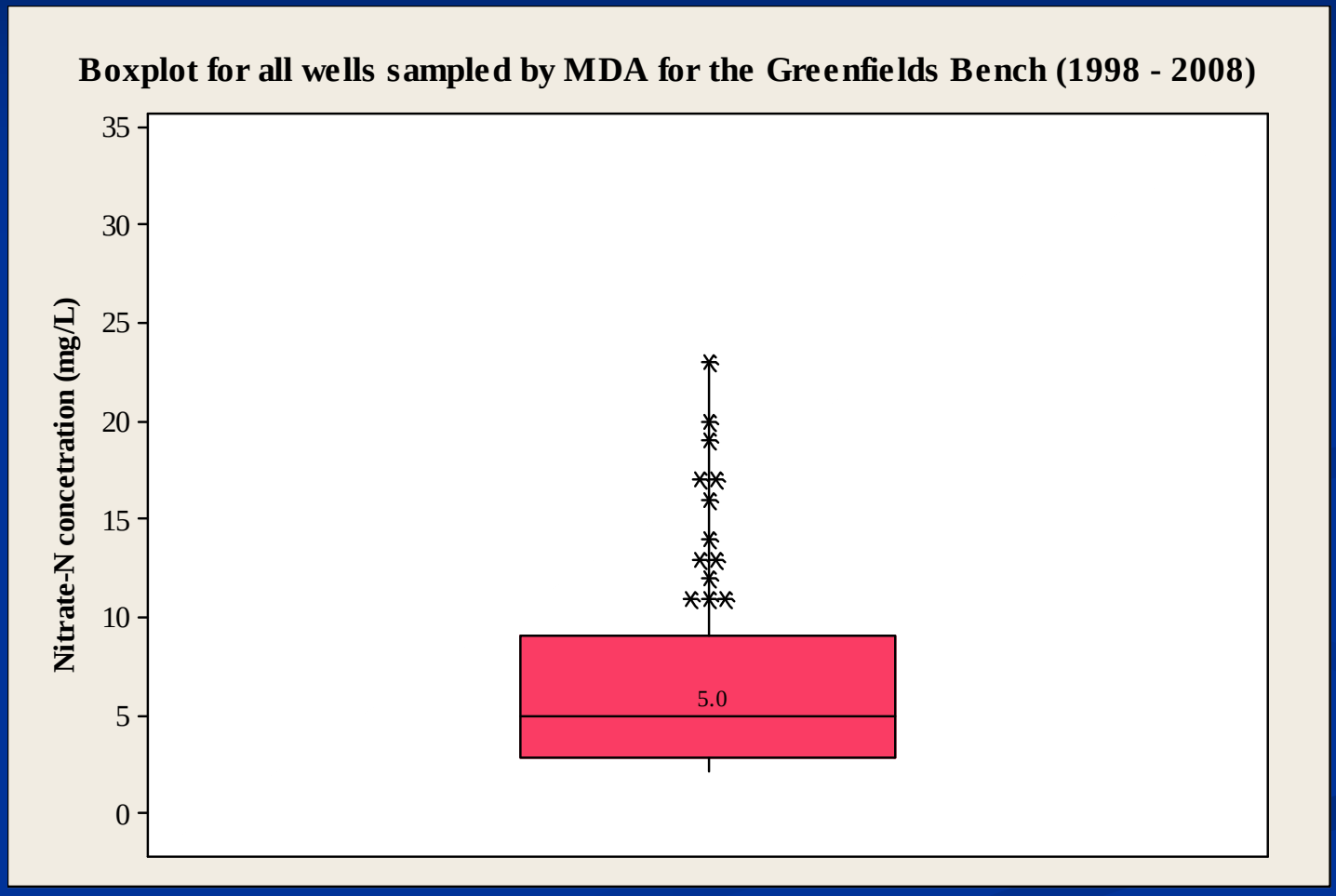
Dataset comparison

Table 1. Well characteristics of all wells on the Greenfields Bench and for two datasets

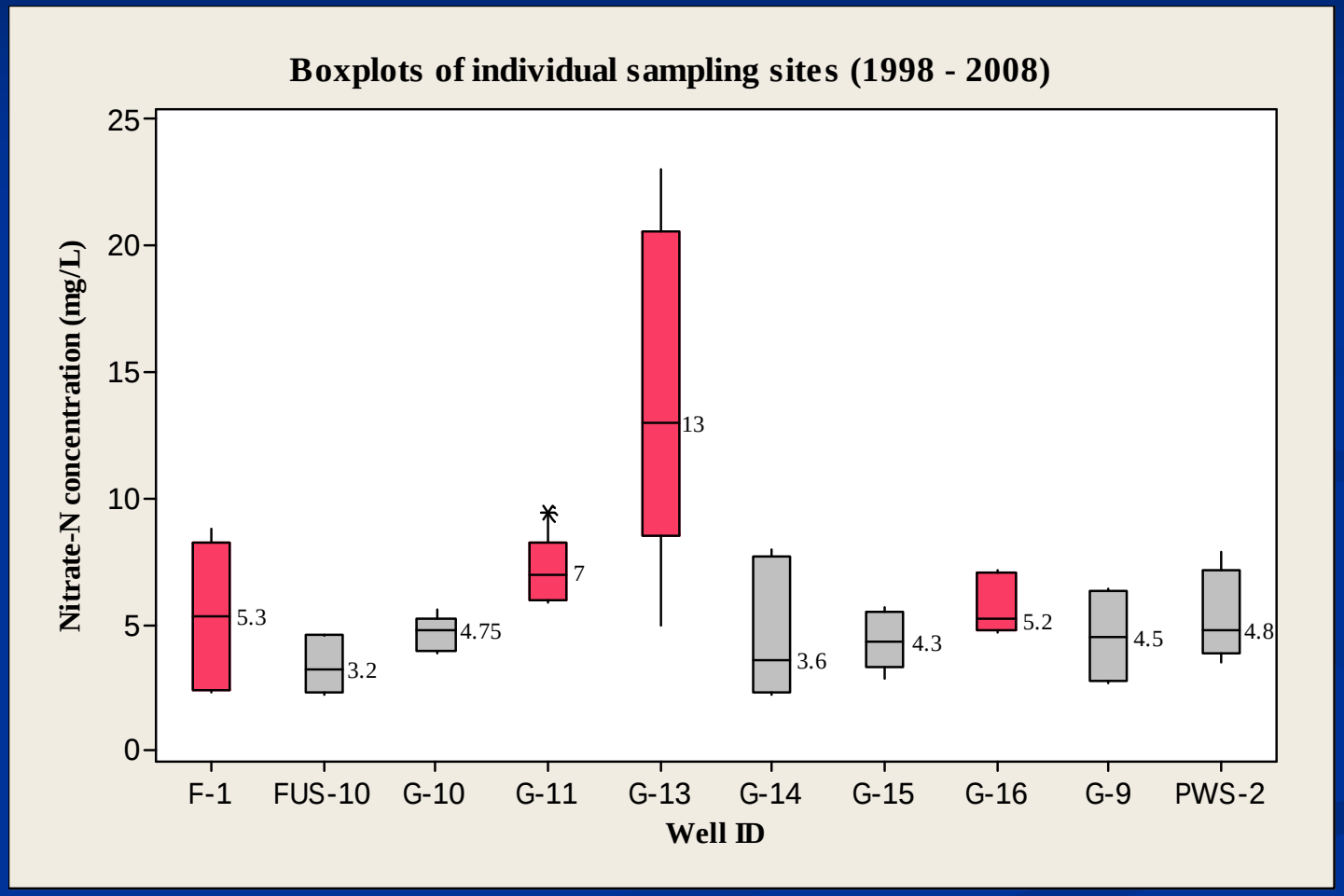
Well characteristics	Greenfields Bench	MDA 1998-2008	Walther 1981
Count	679	10	18
Minimum (ft.)	0.0	14.8	14.0
Maximum (ft.)	285.0	63.0	120.0
Mean (ft.)	28.0	29.1	26.5
Median (ft.)	22.0	25.0	20.0
Std. deviation (ft.)	28.0	14.2	24.1
Con. Level (95%)	2.1	10.2	11.9

- Population means not significantly different (α=0.05) among three datasets for total well depth
- MDA and Walther datasets representative of GWIC database for the Bench

MDA 1998-2008

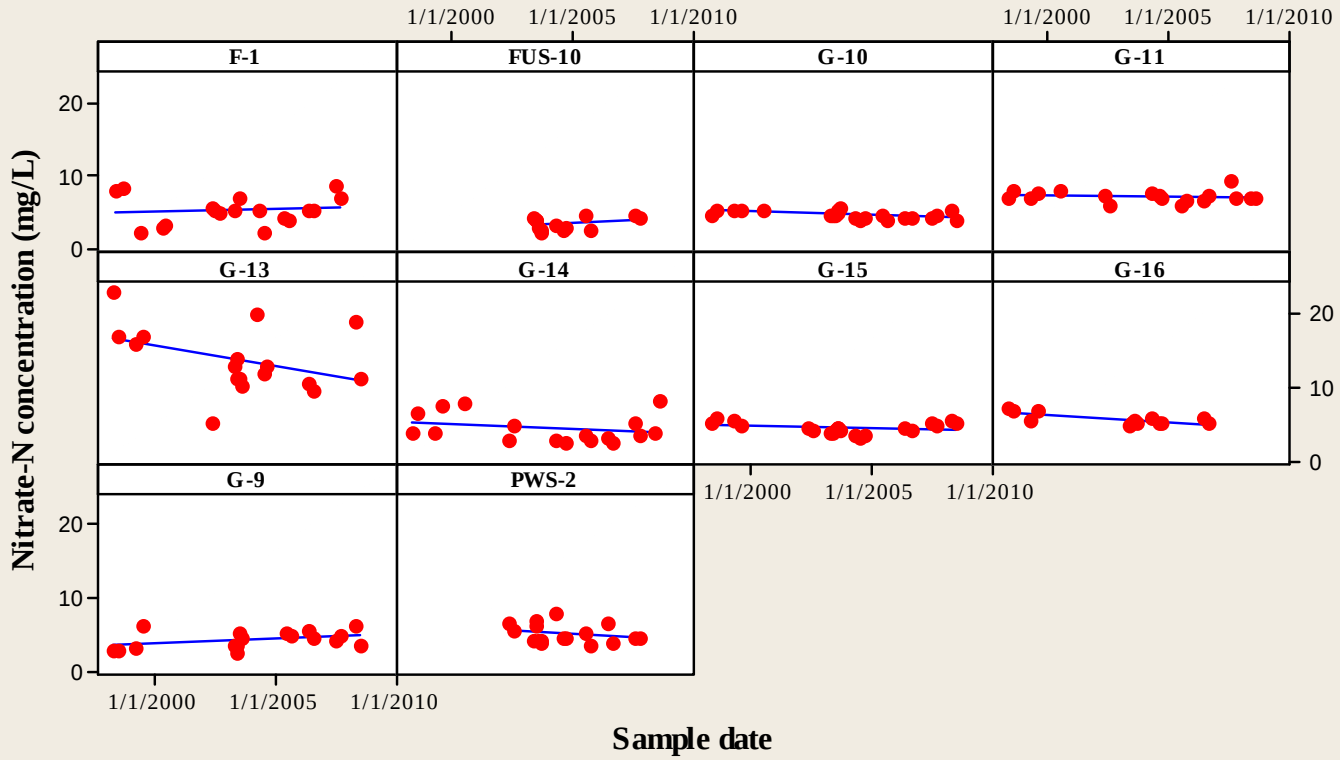


MDA 1998-2008

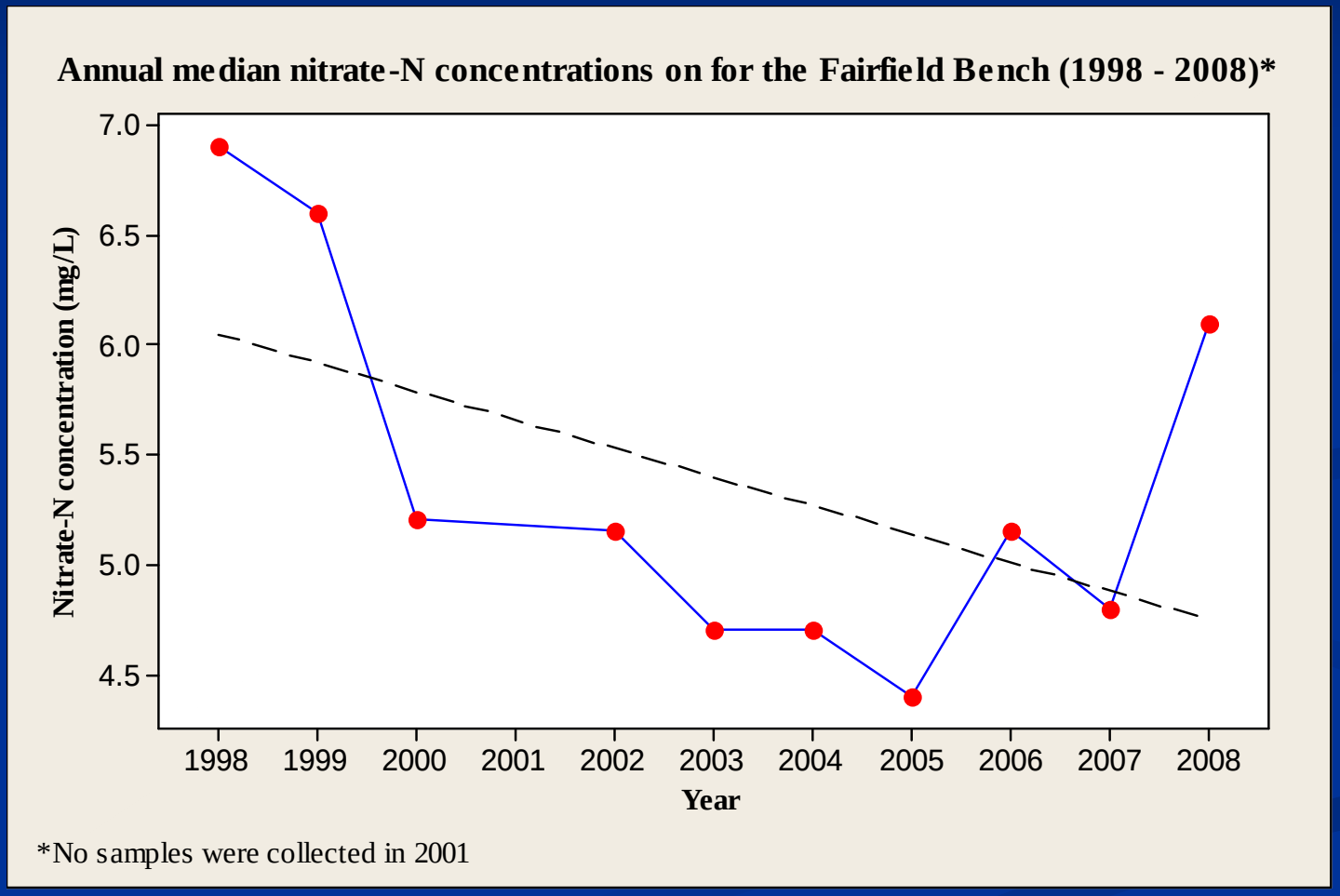


- FUS-10, G-15 and PWS-2 are public drinking water supplies

MDA 1998-2008

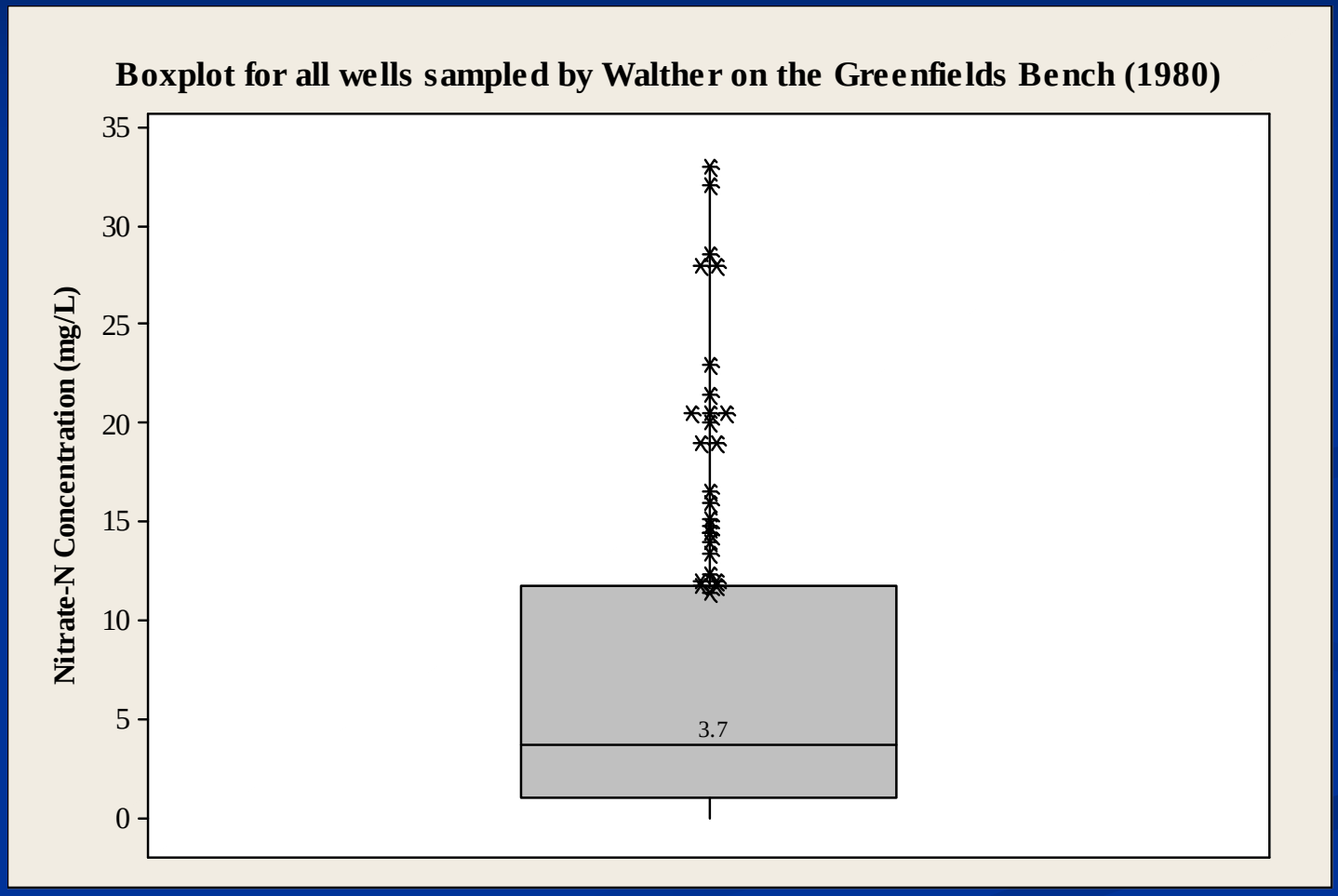


MDA 1998-2008



*No samples were collected in 2001

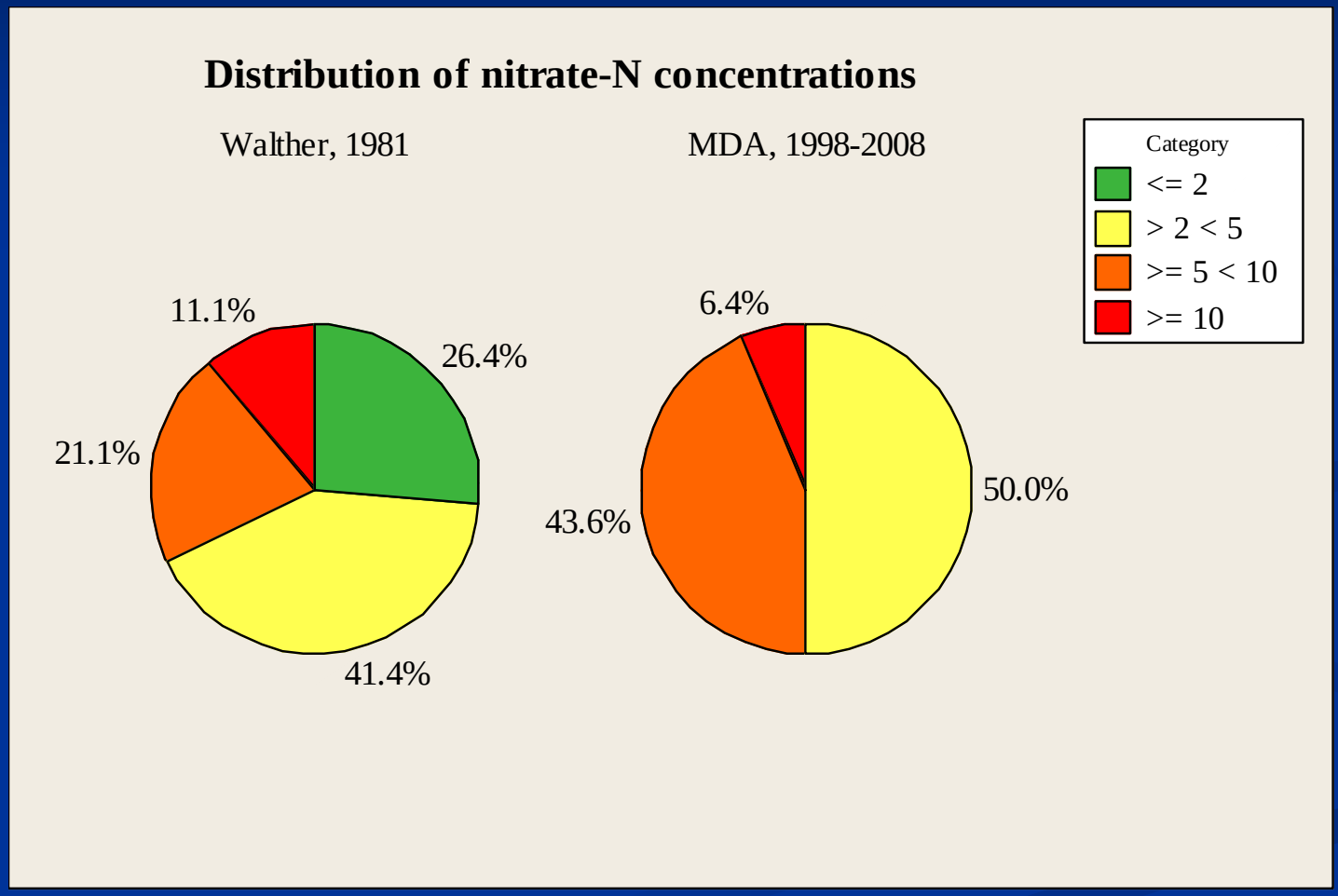
Walther, 1981



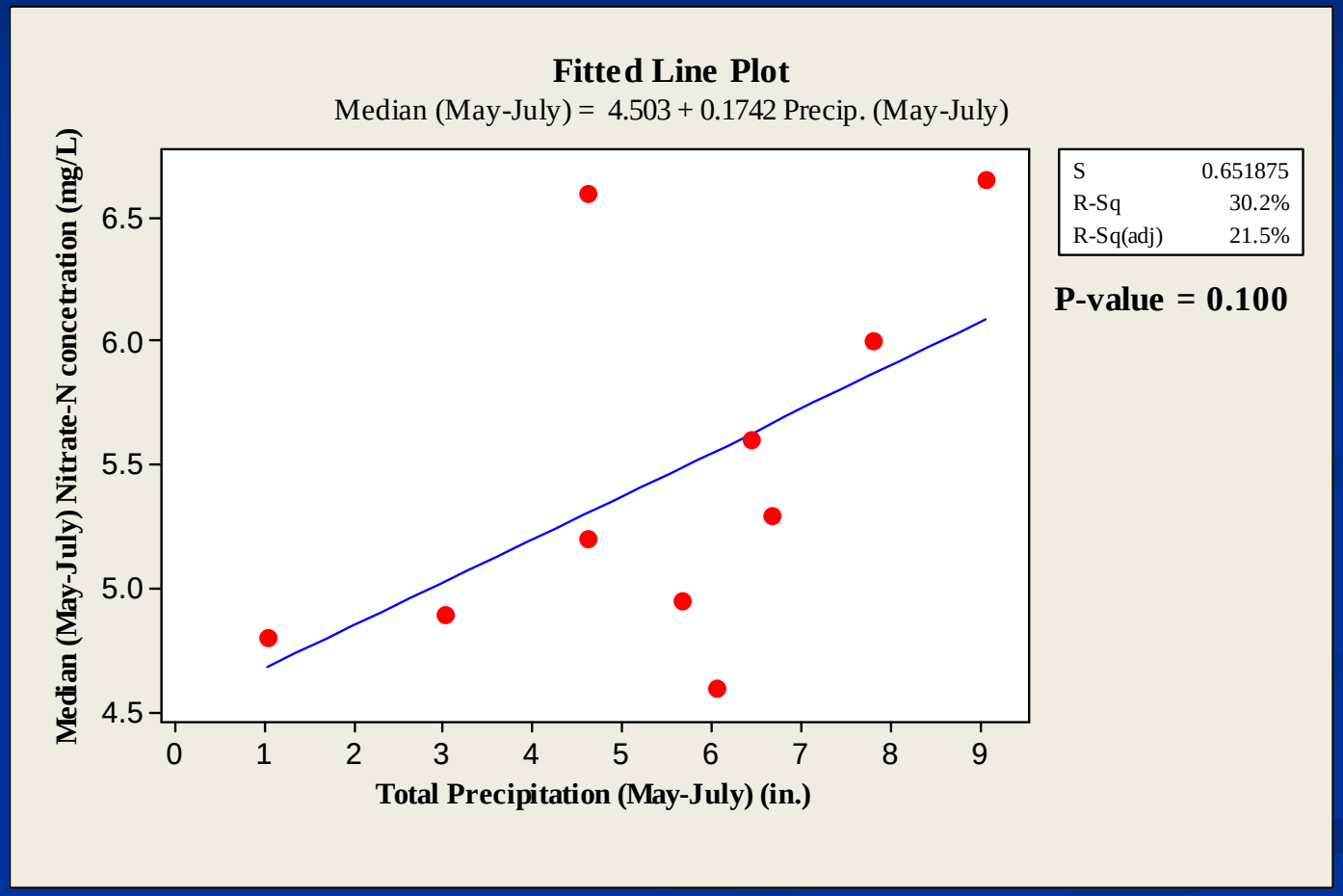
Dataset comparison

- Mean nitrate-N concentrations were not significantly different (α=0.05) between MDA and Walther, 1981 datasets (P-value = 0.107)
- Median nitrate-N concentration greater over 1998-2008 versus 1980 field season
- Significant correlation between nitrate-N concentrations and static water level not observed in either study
  - 1998-2008; P-value = 0.073; PCC = -0.168
    - Shallow groundwater, greater likelihood of elevated nitrate concentrations

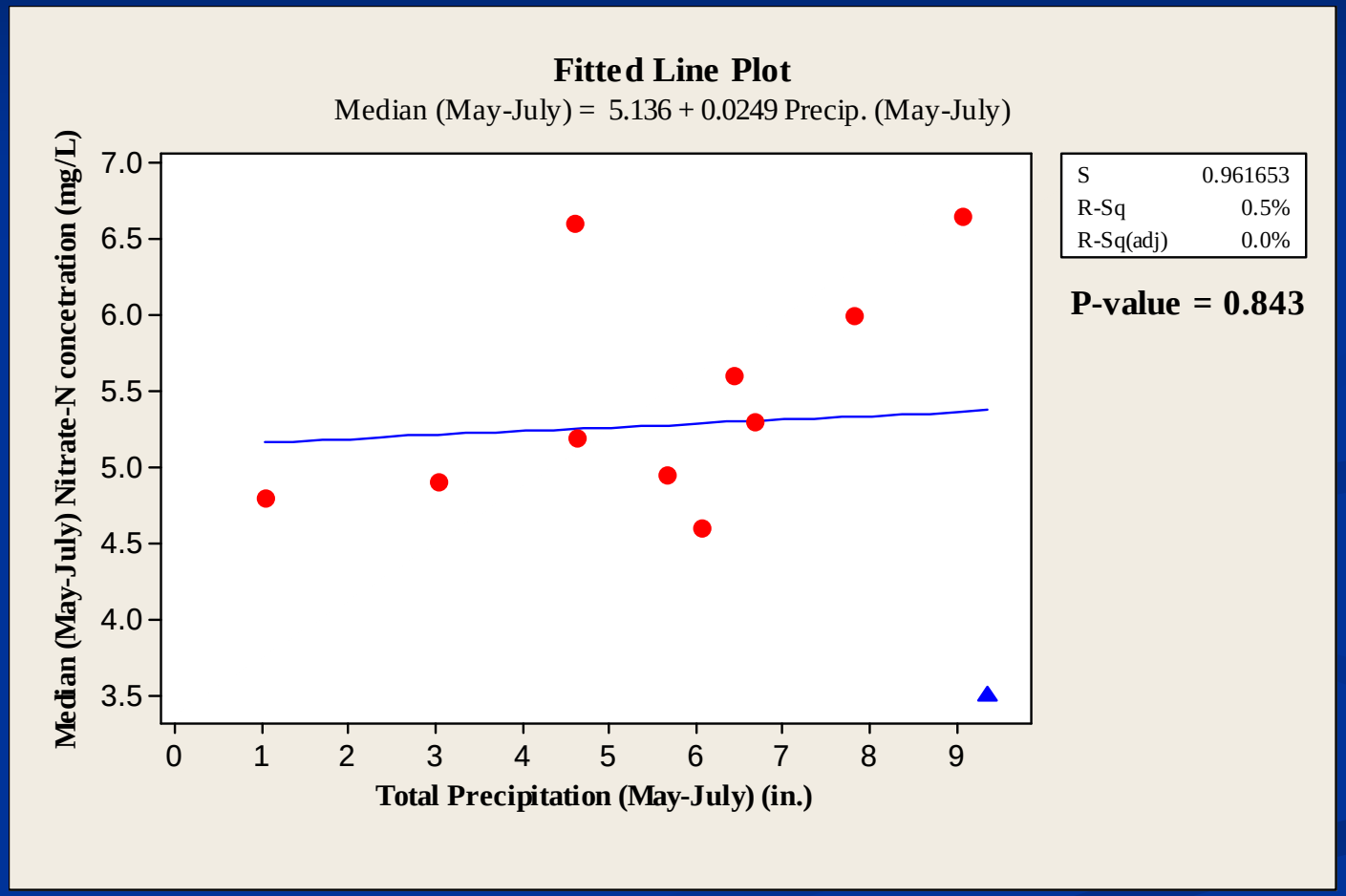
Dataset comparison



Regression analysis



Regression analysis



Irrigation Recharge Rate

- 1980 – 90% flood irrigation, 10% sprinkler (Walther, 1981)
- 2002 – 55-60% flood irrigation, 40-45% sprinkler (wheel-line; center pivot) (Miller et al., 2002)
  - Sprinkler-use increasing in grains vs. alfalfa/hay
- Irrigation efficiency study (Miller, 2005)
  - Wheel-line: 9 cm of recharge (70% < flood)
  - Center pivot: 3 cm of recharge (90% < flood)
- 1998 isotope study – N predominantly nitrate and ammonium fertilizer; possibly SON (*n*=16) (D.A. Nimick, written commun.,1998)

Conclusions

- Recharge rate influenced by irrigation method
  - Rate decreasing with increasing sprinkler irrigation
- Dropping water table due to decrease in summer precipitation and lack of irrigation recharge
- Soil as a N reservoir – susceptible to 'flushing' events particularly during wet season (May-July)
- Nitrate-N not a risk to human health on the Greenfields Bench but may pose future threat

Bibliography

- Miller, K.J., D.S. Rise, and C. McDonald. 2002. Ground-water and surface-water quality, herbicide transport, and irrigation practices: Greenfields Bench Aquifer, Teton County, Montana. MBMG Open-File Report 463.
- Miller, K.J. 2005. Irrigation methods and transport of imazamethabenz-methyl to ground water: Greenfields Bench, Montana. Journal of American Water Resources Association. Paper no. 04014. pp. 257-265
- Osborne, T.J., Noble, R.A., Zaluski, M.H., and F.A. Schmidt. 1983. Evaluation of the ground-water contribution to Muddy Creek from the Greenfields Irrigation District: Montana Bureau of Mines and Geology Open-File Report 113, 141 p.
- Walther, K.C. 1981. Nitrates in wells of the Greenfield Irrigation District Fairfield, Montana.Water Quality Bureau Department of Health and Environmental Sciences. WQB Report No. 81-1. 24 p.

Questions?

Christian G. Schmidt
Hydrologist
Montana Department of Agriculture
cschmidt2@mt.gov
(406) 444-5400